



**SERANGOON JUNIOR COLLEGE**  
**General Certificate of Education Advanced Level**  
**Higher 2**

Candidate Name

Class

**CHEMISTRY**

JC2 Preliminary Examination

Paper 1 Multiple Choice

Additional Materials: Data Booklet  
 Optical Mark Sheet (OMS)

**9647/01**

23 Sep 2016

1 hour

**READ THESE INSTRUCTIONS FIRST**

On the separate multiple choice OMS given, write your name, subject title and class in the spaces provided.

Shade correctly your FIN/NRIC number.

There are **40** questions in this paper. Answer **all** questions.

For each question there are four possible answers **A, B, C** and **D**.

Choose the one you consider correct and record your choice using a **soft pencil** on the separate OMS.

Each correct answer will score one mark.

A mark will not be deducted for a wrong answer.

You are advised to fill in the OMS as you go along; no additional time will be given for the transfer of answers once the examination has ended.

Any rough working should be done in this question paper.

**Answer Key:**

1	B	11	B	21	C	31	C
2	D	12	D	22	B	32	D
3	B	13	C	23	D	33	C
4	A	14	B	24	A	34	B
5	D	15	C	25	D	35	A
6	C	16	D	26	D	36	D
7	C	17	D	27	B	37	B
8	D	18	C	28	C	38	A
9	D	19	B	29	C	39	B
10	B	20	B	30	D	40	B

## Suggested Worked Solution for MCQs

1	The relative abundances of the isotopes of a sample of titanium are shown in the table below.						
	Relative Isotopic Mass		46	47	48	49	50
	Relative Abundance		11.2	10.1	100.0	7.3	7.0
What is the relative atomic mass of titanium in this sample?							
	A	48.00					
	B	47.92					
	C	47.90					
	D	47.89					

**Answer: B**

$$\begin{aligned}\text{Relative atomic mass} &= \frac{(46 \times 11.2) + (47 \times 10.1) + (48 \times 100) + (49 \times 7.3) + (50 \times 7)}{11.2 + 10.1 + 100 + 7.3 + 7.0} \\ &= \frac{515.2 + 474.7 + 4800 + 357.7 + 350}{135.6} \\ &= \frac{6497.3}{135.6} = 47.92\end{aligned}$$

2	<p>To identify an oxide of nitrogen, 0.10 mol of the oxide is mixed with an excess of hydrogen and passed over a catalyst at a suitable temperature.</p> $\text{N}_x\text{O}_y \xrightarrow{\text{H}_2(\text{g})} x\text{NH}_3 + y\text{H}_2\text{O}$ <p>The water produced weighs 7.20 g. The ammonia produced is neutralised by 200 cm<sup>3</sup> of 1.0 mol dm<sup>-3</sup> HCl.</p> <p>What is the formula of the oxide of nitrogen?</p>
A	N <sub>2</sub> O
B	NO
C	NO <sub>2</sub>
D	N <sub>2</sub> O <sub>4</sub>
<p><b>Answer: D</b></p> <p>Amt of H<sub>2</sub>O = <math>\frac{7.2}{18} = 0.40</math> mol</p> <p>Amt of NH<sub>3</sub> = <math>\frac{200}{1000} \times 1 = 0.20</math> mol</p>	
<p>Assuming all gases and using Avogadro's Law</p> <p>Comparing mole ratio of N<sub>x</sub>O<sub>y</sub> with NH<sub>3</sub></p> $\frac{1}{x} = \frac{0.10}{0.20} \quad \text{Hence, } x = 2$ <p>Comparing mole ratio of N<sub>x</sub>O<sub>y</sub> with H<sub>2</sub>O</p> $\frac{1}{y} = \frac{0.10}{0.40} \quad \text{Hence, } y = 4$ <p>Formula is N<sub>2</sub>O<sub>4</sub></p>	

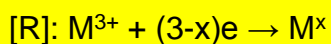
3	<p>50 cm<sup>3</sup> of a 0.10 mol dm<sup>-3</sup> solution of a metallic salt was found to react exactly with 25.0 cm<sup>3</sup> of 0.10 mol dm<sup>-3</sup> aqueous sodium sulfite. In this reaction, the sulfite ion is oxidised as follows.</p> $\text{SO}_3^{2-}(\text{aq}) + \text{H}_2\text{O}(\text{l}) \longrightarrow \text{SO}_4^{2-}(\text{aq}) + 2\text{H}^+(\text{aq}) + 2\text{e}^-$ <p>What is the new oxidation number of the metal in the salt if its original oxidation number was +3?</p>		
	<table border="1"> <tr> <td><b>A</b></td><td>+1</td></tr> </table>	<b>A</b>	+1
<b>A</b>	+1		
	<table border="1"> <tr> <td><b>B</b></td><td>+2</td></tr> </table>	<b>B</b>	+2
<b>B</b>	+2		
	<table border="1"> <tr> <td><b>C</b></td><td>+4</td></tr> </table>	<b>C</b>	+4
<b>C</b>	+4		
	<table border="1"> <tr> <td><b>D</b></td><td>+5</td></tr> </table>	<b>D</b>	+5
<b>D</b>	+5		

**Answer: B**

$$\text{Amount of sulphite ions} = \frac{25}{1000} \times 0.10 = 0.0025 \text{ mol}$$

$$\text{Amount of metallic salt} = \frac{50}{1000} \times 0.10 = 0.005 \text{ mol}$$

Let x be the new oxidation no of metal in salt.



Since moles of electrons gained = moles of electrons lost in a redox reaction,

$$\frac{3-x}{2} = \frac{0.0025}{0.005}$$

$$x = +2$$

4	Of the following, which is the strongest oxidising agent?		
	<table border="1"> <tr> <td><b>A</b></td><td>O<sub>2</sub><sup>+</sup></td></tr> </table>	<b>A</b>	O <sub>2</sub> <sup>+</sup>
<b>A</b>	O <sub>2</sub> <sup>+</sup>		
	<table border="1"> <tr> <td><b>B</b></td><td>O<sub>2</sub></td></tr> </table>	<b>B</b>	O <sub>2</sub>
<b>B</b>	O <sub>2</sub>		
	<table border="1"> <tr> <td><b>C</b></td><td>O<sub>2</sub><sup>-</sup></td></tr> </table>	<b>C</b>	O <sub>2</sub> <sup>-</sup>
<b>C</b>	O <sub>2</sub> <sup>-</sup>		
	<table border="1"> <tr> <td><b>D</b></td><td>O<sub>2</sub><sup>2-</sup></td></tr> </table>	<b>D</b>	O <sub>2</sub> <sup>2-</sup>
<b>D</b>	O <sub>2</sub> <sup>2-</sup>		

**Answer: A**

Strongest oxidising agent means it will undergo reduction easily and as such will gain electrons.

O<sub>2</sub><sup>+</sup> is positively charged and hence is a stronger electron-acceptor than the other species.

5	<p>Paramagnetism refers to the magnetic state of an atom with one or more unpaired electrons. The greater the number of unpaired electrons in an atom, the greater the paramagnetism.</p> <p>Which atom has the greatest paramagnetism?</p>		
	<table border="1"> <tr> <td data-bbox="272 439 320 472"><b>A</b></td><td data-bbox="320 439 1402 472">Oxygen</td></tr> </table>	<b>A</b>	Oxygen
<b>A</b>	Oxygen		
	<table border="1"> <tr> <td data-bbox="272 472 320 506"><b>B</b></td><td data-bbox="320 472 1402 506">Chlorine</td></tr> </table>	<b>B</b>	Chlorine
<b>B</b>	Chlorine		
	<table border="1"> <tr> <td data-bbox="272 506 320 539"><b>C</b></td><td data-bbox="320 506 1402 539">Scandium</td></tr> </table>	<b>C</b>	Scandium
<b>C</b>	Scandium		
	<table border="1"> <tr> <td data-bbox="272 539 320 573"><b>D</b></td><td data-bbox="320 539 1402 573">Arsenic</td></tr> </table>	<b>D</b>	Arsenic
<b>D</b>	Arsenic		
<p><b>Answer: D</b></p> <p>O: <math>1s^2 2s^2 2p^4 \rightarrow 2</math> unpaired electrons in the 2p orbital</p> <p>Cl: <math>[\text{Ne}] 3s^2 3p^5 \rightarrow 1</math> unpaired electron in the 3p orbital</p> <p>Sc: <math>[\text{Ar}] 3d^1 4s^2 \rightarrow 1</math> unpaired electron in the 3d orbital</p> <p>As: <math>[\text{Ar}] 3d^{10} 4s^2 4p^3 \rightarrow \underline{\text{3 unpaired electrons}}</math> in the 4p orbital</p>			

6	Which of the following is true of both real and ideal gases?		
	<table border="1"> <tr> <td data-bbox="272 1039 320 1075"><b>A</b></td><td data-bbox="320 1039 1402 1075">Molecules can be liquefied.</td></tr> </table>	<b>A</b>	Molecules can be liquefied.
<b>A</b>	Molecules can be liquefied.		
	<table border="1"> <tr> <td data-bbox="272 1075 320 1108"><b>B</b></td><td data-bbox="320 1075 1402 1108">Molecules occupy a finite volume.</td></tr> </table>	<b>B</b>	Molecules occupy a finite volume.
<b>B</b>	Molecules occupy a finite volume.		
	<table border="1"> <tr> <td data-bbox="272 1108 320 1144"><b>C</b></td><td data-bbox="320 1108 1402 1144">Molecules are in constant random motion.</td></tr> </table>	<b>C</b>	Molecules are in constant random motion.
<b>C</b>	Molecules are in constant random motion.		
	<table border="1"> <tr> <td data-bbox="272 1144 320 1178"><b>D</b></td><td data-bbox="320 1144 1402 1178">Molecules behave identically at high pressure and low temperature.</td></tr> </table>	<b>D</b>	Molecules behave identically at high pressure and low temperature.
<b>D</b>	Molecules behave identically at high pressure and low temperature.		
<p><b>Answer: C</b></p> <p>Molecules can be liquefied. (Not true - ideal gas do not exert attractive forces on one another)</p> <p>Molecules occupy a finite volume. (Not true - the size of the ideal gas molecule is assumed to be negligible compared to the volume of the container it occupies)</p> <p>Molecules are in constant random motion. (True)</p> <p>Molecules behave identically at high pressure and low temperature. (Not true – real gases behave most ideally at high temperature and low pressure)</p>			

7	The Valence Shell Electron Pair Repulsion Theory (VSEPR) is used to predict the shapes of molecules.			
	Which shape is correctly predicted by VSEPR?			
		<b>number of regions of electron density</b>	<b>number of lone pairs</b>	<b>shape</b>
	<b>A</b>	3	1	Tetrahedral
	<b>B</b>	3	1	Trigonal pyramidal
	<b>C</b>	5	1	See-saw
	<b>D</b>	5	1	Square pyramidal

**Answer: C**  
5 regions of electron density consisting of 1 lone pair → see-saw shape

For example,  $\begin{array}{c} \text{F} \\ | \\ \text{:S} \text{---} \text{F} \\ | \quad \diagup \quad \diagdown \\ \text{F} \quad \text{F} \quad \text{F} \end{array}$  has a see-saw shape

8	<p>The magnitude of the lattice energy of calcium oxide and calcium carbonate is <math>3414 \text{ kJ mol}^{-1}</math> and <math>2814 \text{ kJ mol}^{-1}</math> respectively. The enthalpy change of decomposition of calcium carbonate is <math>+176 \text{ kJ mol}^{-1}</math>.</p> <p>Using the information provided, calculate the enthalpy change of the following reaction.</p> $\text{CO}_3^{2-}(\text{g}) \rightarrow \text{O}^{2-}(\text{g}) + \text{CO}_2(\text{g})$		
	<b>A</b>	- $424 \text{ kJ mol}^{-1}$	
	<b>B</b>	+ $424 \text{ kJ mol}^{-1}$	
	<b>C</b>	- $776 \text{ kJ mol}^{-1}$	
	<b>D</b>	+ $776 \text{ kJ mol}^{-1}$	

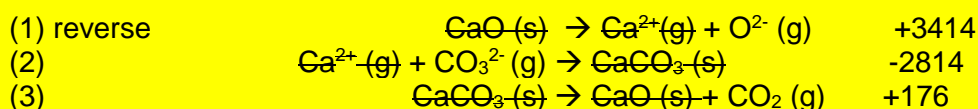
**Answer: D**

$$\begin{array}{ccc}
 \text{Ca}^{2+}(\text{g}) + \text{CO}_3^{2-}(\text{g}) & \xrightarrow{\Delta H_{\text{reaction}}} & \text{O}^{2-}(\text{g}) + \text{CO}_2(\text{g}) + \text{Ca}^{2+}(\text{g}) \\
 \downarrow \text{LE}(\text{CaCO}_3) = -2814 & & \downarrow \text{LE}(\text{CaO}) = -3414 \\
 \text{CaCO}_3(\text{s}) & \xrightarrow{\Delta H_{\text{decomposition}} = +176} & \text{CaO}(\text{s}) + \text{CO}_2(\text{g})
 \end{array}$$

By Hess Law  
 $\Delta H_{\text{reaction}} + \text{LE}(\text{CaO}) = \text{LE}(\text{CaCO}_3) + \Delta H_{\text{decomposition of CaCO}_3}$   
 $\Delta H_{\text{reaction}} = \text{LE}(\text{CaCO}_3) + \Delta H_{\text{decomposition of CaCO}_3} - \text{LE}(\text{CaO})$   
 $\Delta H_{\text{reaction}} = -2814 + 176 + 3414 = +776 \text{ kJ mol}^{-1}$

Or  
 Using algebraic method:  
 (1)  $\text{Ca}^{2+}(\text{g}) + \text{O}^{2-}(\text{g}) \rightarrow \text{CaO}(\text{s})$  -3414  
 (2)  $\text{Ca}^{2+}(\text{g}) + \text{CO}_3^{2-}(\text{g}) \rightarrow \text{CaCO}_3(\text{s})$  -2814  
 (3)  $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$  +176

Objective :  $\text{CO}_3^{2-}(\text{g}) \rightarrow \text{O}^{2-}(\text{g}) + \text{CO}_2(\text{g})$  ???

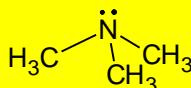
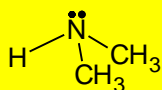
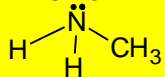


Aim achieved:  $\text{CO}_3^{2-}(\text{g}) \rightarrow \text{O}^{2-}(\text{g}) + \text{CO}_2(\text{g})$  +776

**9** Primary, secondary and tertiary amine have similarly shaped molecules. What is the predominant intermolecular force of attraction in methylamine, dimethylamine and trimethylamine?

		<b>methylamine</b>	<b>dimethylamine</b>	<b>trimethylamine</b>
	<b>A</b>	hydrogen bonds	hydrogen bonds	hydrogen bonds
	<b>B</b>	hydrogen bonds	permanent dipole – permanent dipole	Instantaneous dipole – induced dipole
	<b>C</b>	permanent dipole – permanent dipole	permanent dipole – permanent dipole	permanent dipole – permanent dipole
	<b>D</b>	hydrogen bonds	hydrogen bonds	permanent dipole – permanent dipole

**Answer: D**



(from left to right) the strongest intermolecular force in methylamine, dimethylamine and trimethylamine are hydrogen bonds, hydrogen bonds and permanent dipole – permanent dipole respectively. Trimethylamine does not have hydrogen bonds because there are no hydrogen atoms directly bonded to the nitrogen atom.

**10** The integrated form of first-order rate law is as shown.

$$\ln A = -kt + \ln A_0$$

where A is the activity at time t,  
 $A_0$  is the initial activity,  
 k is the rate constant,  
 t is the time taken.

What is the half-life for a first order reaction if 68% of a substance is reacted within 66s?

- |          |       |
|----------|-------|
| <b>A</b> | 33 s  |
| <b>B</b> | 40 s  |
| <b>C</b> | 49 s  |
| <b>D</b> | 119 s |

**Answer: B**

68% reacted means 32% remain

$$\ln 0.32 = -k(66) + \ln 1$$

$$k = 0.0172642 \text{ s}^{-1}$$

$$\text{Using } t_{1/2} = \frac{\ln 2}{k} \quad t_{1/2} = \frac{\ln 2}{0.0172642} \quad t_{1/2} = 40 \text{ second}$$

OR

$$C_t/C_0 = (1/2)^n$$

$$32/100 = (1/2)^n$$

$$n = 1.644 \quad \text{one half-life} = 66 / 1.644 = 40.15 \text{ s}$$

11	For which equilibrium is $K_c = K_p$ ?
A	$\text{C(s)} + \text{H}_2\text{O(l)} \rightleftharpoons \text{CO(g)} + \text{H}_2\text{(g)}$
B	$\text{H}_2\text{(g)} + \text{I}_2\text{(g)} \rightleftharpoons 2\text{HI(g)}$
C	$\text{N}_2\text{(g)} + 3\text{H}_2\text{(g)} \rightleftharpoons 2\text{NH}_3\text{(g)}$
D	$2\text{NO}_2\text{(g)} \rightleftharpoons \text{N}_2\text{O}_4\text{(g)}$

**Answer: B**

When there are equal number of moles on each side of the stoichiometric equation  
 $K_c = K_p$

considering ideal gases,  $pV = nRT$  which implies

$$\text{Concentration of a gas: } \frac{n}{V} = \frac{p}{RT}$$

Consider the **reversible gaseous** system:  $a\text{A(g)} + b\text{B(g)} \rightleftharpoons c\text{C(g)} + d\text{D(g)}$

$$K_c = \frac{[\text{C}]^c [\text{D}]^d}{[\text{A}]^a [\text{B}]^b} = \frac{\left(\frac{p_C}{RT}\right)^c \left(\frac{p_D}{RT}\right)^d}{\left(\frac{p_A}{RT}\right)^a \left(\frac{p_B}{RT}\right)^b} = \frac{(p_C)^c (p_D)^d}{(p_A)^a (p_B)^b} (RT)^{(a+b)-(c+d)} = K_p \times (RT)^{(a+b)-(c+d)}$$

12	The ionic product of water, $K_w$ , at two different temperatures is shown below,  <table border="1" data-bbox="547 1160 1158 1267"> <thead> <tr> <th><math>K_w / \text{mol}^2 \text{dm}^{-6}</math></th><th>Temperature / K</th></tr> </thead> <tbody> <tr> <td><math>1.00 \times 10^{-14}</math></td><td>298</td></tr> <tr> <td><math>1.44 \times 10^{-14}</math></td><td>303</td></tr> </tbody> </table> Which statement is correct?	$K_w / \text{mol}^2 \text{dm}^{-6}$	Temperature / K	$1.00 \times 10^{-14}$	298	$1.44 \times 10^{-14}$	303
$K_w / \text{mol}^2 \text{dm}^{-6}$	Temperature / K						
$1.00 \times 10^{-14}$	298						
$1.44 \times 10^{-14}$	303						
A	Self-ionisation of water is an exothermic process.						
B	At 303 K, $[\text{H}^+] = 0.72 \times 10^{-14} \text{ mol dm}^{-3}$						
C	$K_w = \frac{[\text{H}^+][\text{OH}^-]}{[\text{H}_2\text{O}]}$						
D	At 303 K, $\text{pH} < 7$						

**Answer: D**

$\text{H}_2\text{O} \rightleftharpoons \text{H}^+ + \text{OH}^-$  is an endothermic process.

At 303:  $K_w = [\text{H}^+][\text{OH}^-]$ ,  $1.44 \times 10^{-14} = x^2$  (where  $x$  is the  $[\text{H}^+]$ )  
 $x = 1.2 \times 10^{-7} \text{ mol dm}^{-3}$   
that means  $[\text{H}^+] = 1.2 \times 10^{-7} \text{ mol dm}^{-3}$   
 $\text{pH} = 6.92 (<7)$

<b>13</b>	Calculate the pH of the resulting solution when 10 cm <sup>3</sup> of potassium hydroxide with concentration at $7.5 \times 10^{-7} \text{ mol dm}^{-3}$ is mixed with an equal volume of hydrogen bromide with concentration at $8.5 \times 10^{-8} \text{ mol dm}^{-3}$ .	
	<b>A</b>	4.18
	<b>B</b>	6.36
	<b>C</b>	7.64
	<b>D</b>	9.82

**Answer: C**



Amt of KOH =  $7.5 \times 10^{-9} \text{ mol}$     Amt of HBr =  $8.5 \times 10^{-10} \text{ mol}$

Since HBr is the limiting reagent and KBr is a neutral salt, the remaining KOH will account for the pH. Thus, the pH of the resulting solution must be greater than 7. Note that there is no buffer solution for strong acid vs strong base reaction.

Amt of KOH left =  $6.65 \times 10^{-9} \text{ mol}$

$$[\text{OH}^-] = 6.65 \times 10^{-7} / 0.02 = 3.32 \times 10^{-7}$$

$$\text{Total } [\text{OH}^-] = 3.32 \times 10^{-7} + 1 \times 10^{-7} =$$

(dissociation of water must be considered as the concentration of the base and acid is very low)

$$\text{pOH} = 6.36$$

$$\text{pH} = 7.64$$

<b>14</b>	Aqueous hydrochloric acid was electrolysed for ten minutes, 200 cm <sup>3</sup> of gas <b>A</b> was collected at the anode.  The same current was then applied to concentrated sodium chloride solution in another experiment and 400 cm <sup>3</sup> of a gas <b>B</b> is collected at the cathode.  Which of these statements is correct?	
	<b>A</b>	Gas <b>B</b> is pale yellow.
	<b>B</b>	The time taken for the second electrolysis is also ten minutes.
	<b>C</b>	Chlorine gas was collected initially in the first electrolysis system.
	<b>D</b>	Mercury electrodes can be used for the second electrolysis system if gas <b>B</b> is to be collected.

**Answer: B**

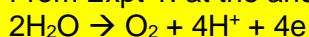
Option A is incorrect because the gas collected at the cathode is H<sub>2</sub>.

Option C is wrong because the gas collected at the anode is O<sub>2</sub>.

Option D is wrong because mercury electrodes will cause sodium to be selectively discharged at the cathode of the second electrolysis.

Option B is correct and the following shows the calculation:

From Expt 1: at the anode



$$\frac{0.2}{24} = \frac{I \times 10 \times 60}{4 \times 96500} \quad \text{solving } I = 5.361 \text{ A}$$

From Expt 2: At the cathode



Considering same current used in Expt 1

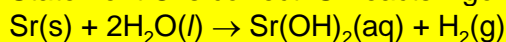
$$\frac{0.4}{24} = \frac{5.361 \times \text{time}}{2 \times 96500}, \quad \text{solving time} = 10 \text{ min}$$



<b>15</b>	Which of the following properties could be predicted for strontium or its compounds?	
	<b>A</b>	It does not burn in air.
	<b>B</b>	It forms a soluble sulfate.
	<b>C</b>	It reacts with cold water, liberating hydrogen.
	<b>D</b>	It forms a water-soluble carbonate which does not decompose on heating.

**Answer: C**

Statement C is correct. Sr reacts vigorously with cold water.



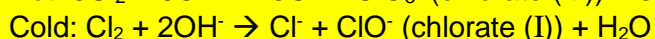
Sr burns very fast in air to produce a white oxide.  $2\text{Sr(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{SrO(s)}$

$\text{SrSO}_4$  is not soluble in water as solubility of Group II sulfate decreases down the Group.

$\text{SrCO}_3$  is not a water soluble compound and its reasoning is similar to its sulfate.

<b>16</b>	Equal volumes of chlorine gas were bubbled into hot and cold sodium hydroxide separately until reactions were complete.  Which of the following statements is incorrect about the above reactions?	
	<b>A</b>	Disproportionation reactions will occur.
	<b>B</b>	Greenish-yellow chlorine gas decolourises in both reactions.
	<b>C</b>	When aqueous silver nitrate is added to the resulting solutions, white precipitate is formed.
	<b>D</b>	Sodium chlorate(VII) and sodium chlorate(I) are formed in the reactions respectively.

**Answer: D**



The reactions involved are disproportionation reaction and the greenish yellow chlorine gas will decolourised as it was reacted away. White ppt of silver chloride will be generated when  $\text{AgNO}_3$  is added.

17	Aqueous chlorine is added to aqueous sodium bromide and the mixture is shaken with an equal volume of trichloromethane.	
	Which observation will be made?	
	A	The solution in the test-tube turns colourless.
	B	The solution in the test-tube turns orange.
	C	A colourless layer forms on top of a purple layer.
	D	A colourless layer forms on top of an orange layer.

**Answer: D**

Chlorine is a strong oxidising agent and the bromide ion will be oxidised to bromine.



When trichloromethane (an organic solvent) is added, the  $\text{Br}_2$  will dissolve in this organic layer forming an orange layer. The aqueous layer may be pale yellow (if concentration of bromine formed is high) or colourless (if concentration of bromine is low).

Option C is out as iodine (which is purple) is not formed in this reaction.

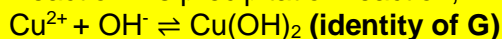
Option A and B are out as water and trichloromethane exist as immiscible liquid.

18	A reaction scheme starting from aqueous copper(II) sulfate solution is shown below. Both <b>G</b> and <b>H</b> are copper-containing species.	
	$\text{CuSO}_4(\text{aq}) \xrightarrow[\text{I}]{\text{NH}_3(\text{aq})} \text{G} \xrightarrow[\text{II}]{\text{excess NH}_3(\text{aq})} \text{H} \xrightarrow[\text{III}]{\text{Na}_4\text{edta}(\text{aq})} [\text{Cu}(\text{edta})]^{2-}(\text{aq})$	
	Which of the following statements is correct?	
	A	Reaction III is a redox reaction.
	B	$\text{NH}_3$ acts as a ligand in reaction I.
	C	<b>H</b> is a deep blue solution containing $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]\text{SO}_4$ .
	D	The entropy of the system decreases when reaction III occurs.

**Answer: C**

Reaction III is ligand exchange reaction, hence no redox occurs. Also, same no. of bonds are broken and formed, hence no change in entropy.

Reaction I is precipitation reaction,  $\text{NH}_3 + \text{H}_2\text{O} \rightleftharpoons \text{OH}^- + \text{NH}_4^+$



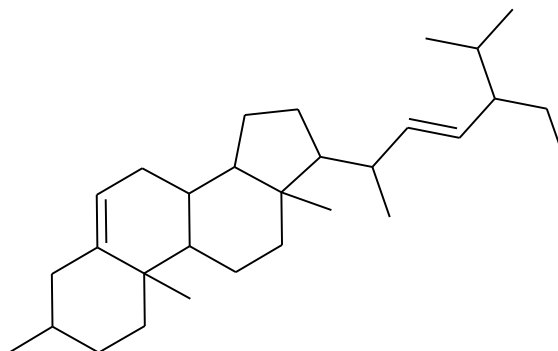
**G**,  $\text{Cu}(\text{OH})_2$ , is soluble in excess  $\text{NH}_3$  to form **H**,  $[\text{Cu}(\text{NH}_3)_4(\text{H}_2\text{O})_2]\text{SO}_4$ , a deep blue solution.

When  $\text{Na}_4\text{edta}$  was added, ligand exchange reaction occurs



Entropy of the system increases due to the release of  $\text{NH}_3$  and water molecules.

**19** Stigmasterol is an unsaturated plant sterol occurring in the plant fats of soybean.



How many stereoisomers does stigmasterol have?

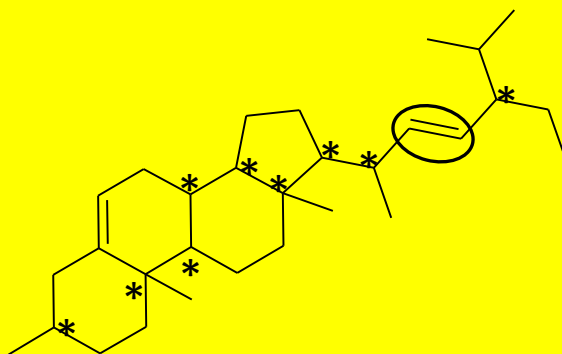
**A**  $2^9$

**B**  $2^{10}$

**C**  $2^{11}$

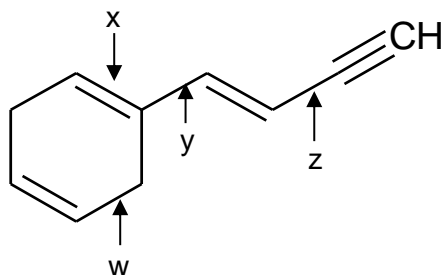
**D**  $2^{12}$

**Answer: B**



There are 9 chiral carbon centres and 1 double bond which can exhibit geometrical isomerism. Hence, the total number of stereoisomers is  $2^{9+1} = 2^{10}$

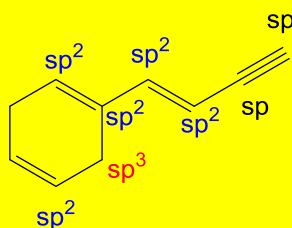
20. Four carbon-carbon bonds are labelled in the diagram.



Which bonds are made up of a  $sp^2$ - $sp^2$  overlap?

- A** x only
- B** x and y only
- C** w, x and y only
- D** w, y and z only

**Answer: B**

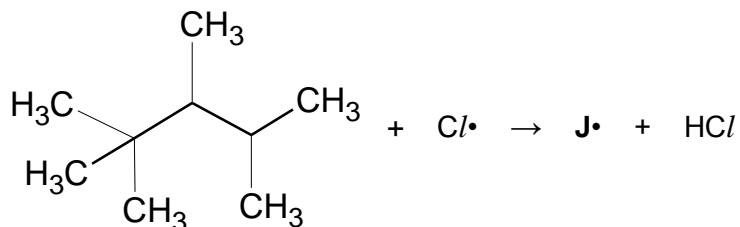


Bond **x** and **y** comprises of  $sp^2$  –  $sp^2$  overlap.

Bond **w** comprises of  $sp^2$  –  $sp^3$  overlap.

Bond **z** comprises of  $sp^2$  –  $sp$  overlap.

21. When heated with chlorine, the hydrocarbon 2,2,3,4-tetramethylpentane undergoes free radical substitution. In a propagation step, the free radical  $\text{J}\cdot$  is formed by the loss of one hydrogen atom.



How many different forms of  $\text{J}\cdot$  are theoretically possible?

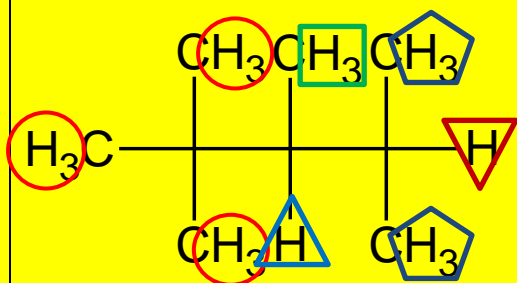
A 3

B 4

C 5

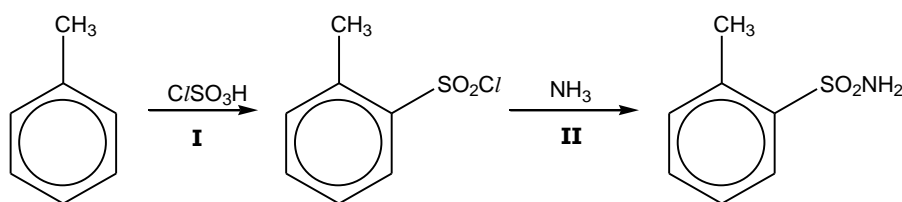
D 6

Answer: C



There are 5 possible sites (as indicated by the shapes) to lose one hydrogen to form different free radical.

- 22** Saccharin was an artificial sweetener used in some soft drinks. It was manufactured from methylbenzene by a series of reactions.



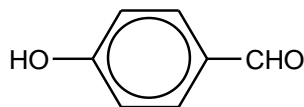
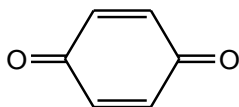
Which of the following shows the correct reaction type for steps I and II?

	I	II
A	Electrophilic substitution	Electrophilic addition
B	Electrophilic substitution	Nucleophilic substitution
C	Nucleophilic substitution	Nucleophilic substitution
D	Nucleophilic substitution	Electrophilic substitution

**Answer: B**

The first reaction involves the  $\text{SO}_2\text{Cl}^+$  being substituted into the benzene ring.  
The second reaction involves the  $\text{NH}_3$  nucleophilic substitution with the  $\text{RSO}_2\text{Cl}$ .

- 23** Which of the following **cannot** be used to distinguish between the following compounds?



A	Hot acidified $\text{K}_2\text{Cr}_2\text{O}_7$
B	Neutral iron(III) chloride
C	Diammine silver complex
D	Phenylhydrazine

**Answer: D**

Option A can be used. undergo oxidation with  $\text{Cr}_2\text{O}_7^{2-}$  to form .

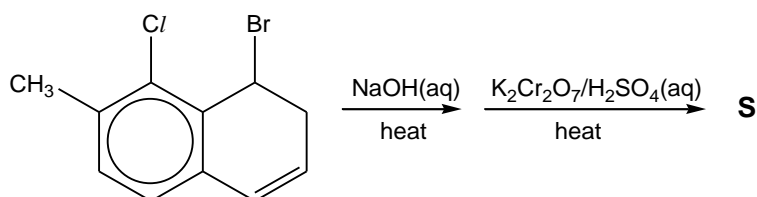
Option B is possible as will form a violet complex.

Option C, Tollen's reagent can be used to identify . A silver mirror will be formed upon heating.

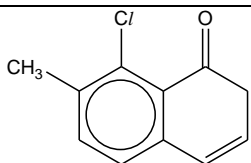
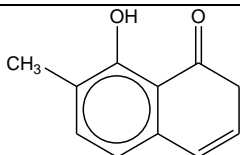
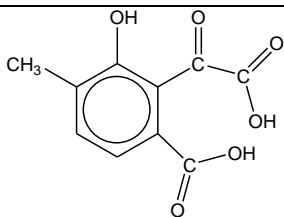
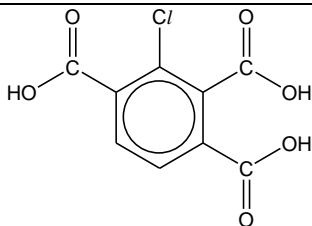
Option D cannot be used as both compounds have carbonyl compound which can form orange ppt with phenylhydrazine.

24

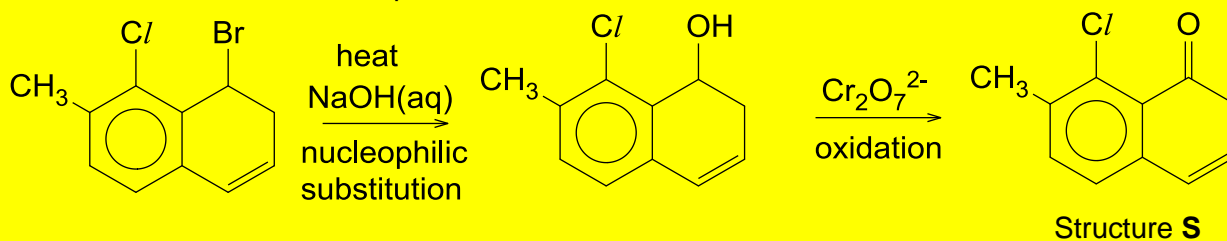
The reaction scheme below shows the synthesis of compound **S**.



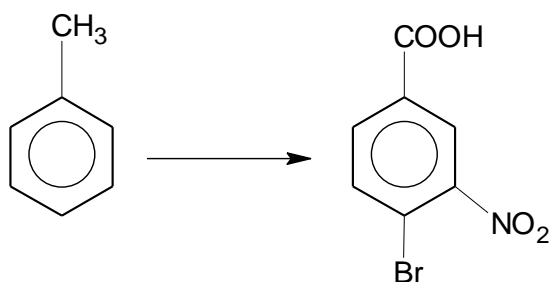
Which of the following can be **S**?

**A****B****C****D****Answer: A**

The reaction scheme for this question is shown below.



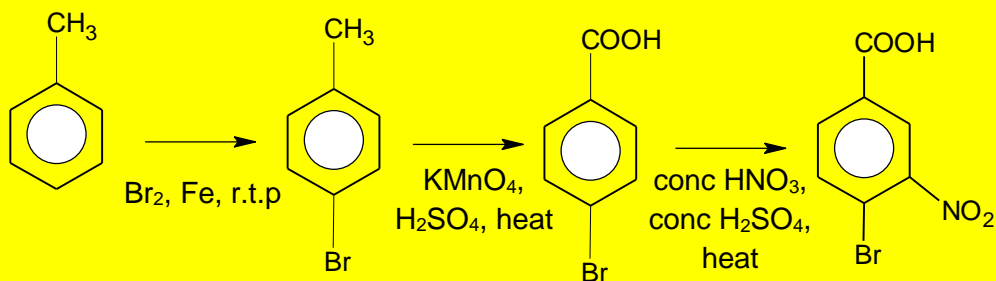
25 The following synthetic route consists of three steps.



Which sequence of steps would give the highest yield?

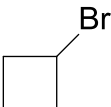
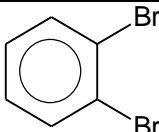
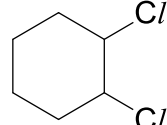
	Step 1	Step 2	Step 3
A	KMnO <sub>4</sub> , H <sub>2</sub> SO <sub>4</sub> , heat	conc HNO <sub>3</sub> , conc H <sub>2</sub> SO <sub>4</sub> , heat	Br <sub>2</sub> , Fe, r.t.p
B	conc HNO <sub>3</sub> , conc H <sub>2</sub> SO <sub>4</sub> , heat	Br <sub>2</sub> , Fe, r.t.p	KMnO <sub>4</sub> , H <sub>2</sub> SO <sub>4</sub> , heat
C	Br <sub>2</sub> , Al/Br <sub>3</sub> , r.t.p	conc HNO <sub>3</sub> , dilute H <sub>2</sub> SO <sub>4</sub> , heat	KMnO <sub>4</sub> , H <sub>2</sub> SO <sub>4</sub> , heat
D	Br <sub>2</sub> , Fe, r.t.p	KMnO <sub>4</sub> , H <sub>2</sub> SO <sub>4</sub> , heat	conc HNO <sub>3</sub> , conc H <sub>2</sub> SO <sub>4</sub> , heat

**Answer: D**

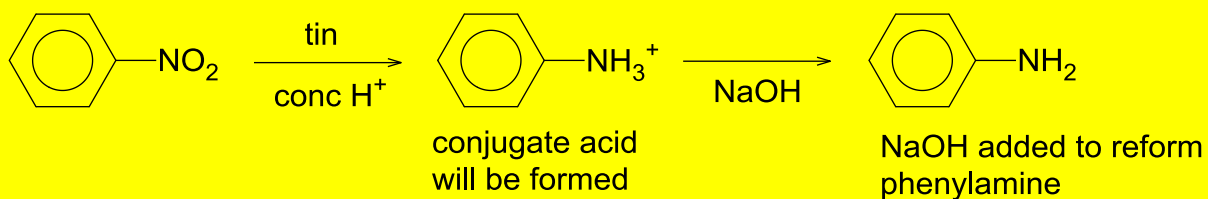


Please note that concentrated HNO<sub>3</sub> and concentrated H<sub>2</sub>SO<sub>4</sub> must be used for electrophilic substitution of benzene ring.

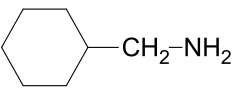
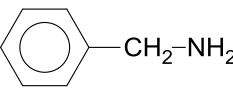
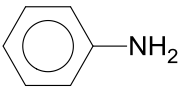
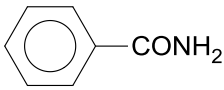
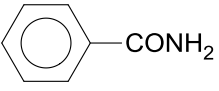
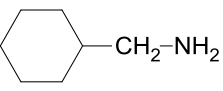
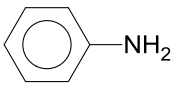
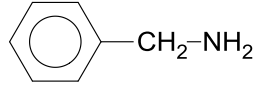
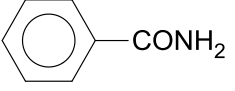
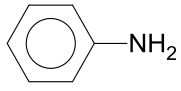
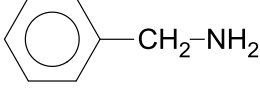
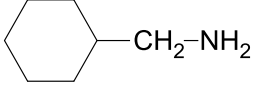
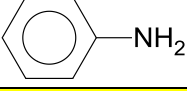
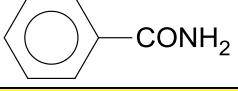
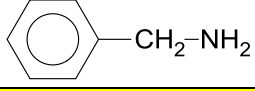
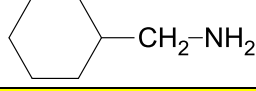


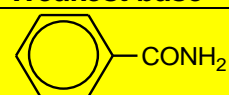
26	<p>Ten grams of each of the following was heated for a prolong period of time with NaOH(aq). Subsequently, dilute HNO<sub>3</sub>(aq) and AgNO<sub>3</sub>(aq) were added.</p> <p>Which compound will produce the greatest mass of AgBr(s)?</p>			
	<p><b>A</b></p>  <p>(<math>M_r = 134.9</math>)</p>	<p><b>C</b></p>  <p>(<math>M_r = 235.8</math>)</p>		
	<p><b>B</b></p> <p>CH<sub>3</sub>COC(=O)Cl (<math>M_r = 78.5</math>)</p>	<p><b>D</b></p>  <p>(<math>M_r = 153.0</math>)</p>		
<p><b>Answer: D</b></p> <p>Upon heating with NaOH (aq), nucleophilic substitution will occur and all possible halogenoalkanes and acyl halides will undergo nucleophilic substitution.</p> <p>For Option A  Amount of organic cpd = <math>10/134.9 = 0.074</math> mol  Amt of Br<sup>-</sup> substituted = 0.074 mol  Mass of AgBr ppted = <math>0.074 \times (108 + 79.9) = 13.9</math> g</p> <p>For Option B  Amount of organic cpd = <math>10/78.5 = 0.127</math> mol  Amt of Cl<sup>-</sup> substituted = 0.127 mol  Mass of AgCl ppted = <math>0.127 \times (108 + 35.5) = 18.3</math> g</p> <p>For Option C  No nucleophilic substitution took place.</p> <p>For Option D  Amount of organic cpd = <math>10/153 = 0.0653</math> mol  Amt of Cl<sup>-</sup> substituted = <math>0.0653 \times 2 = 0.131</math> mol  Mass of AgCl ppted = <math>0.131 \times (108 + 35.5) = \mathbf{18.8\text{ g}}</math></p>				

<b>27</b>	After the reduction using tin and concentrated acid of nitrobenzene to phenylamine, an excess of sodium hydroxide is added.  What is the purpose of the sodium hydroxide?	
	<b>A</b>	to dry the product
	<b>B</b>	to liberate the phenylamine
	<b>C</b>	to neutralise the excess acid
	<b>D</b>	to lower the boiling point for subsequent distillation

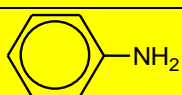
**Answer: B**

The main role of NaOH is not to neutralise the concentrated acid but rather to react with the conjugate acid to form the phenylamine.

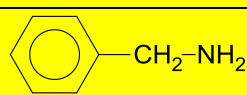
<b>28</b>	Which of the following shows the correct order of basicity?			
	<b>Weakest base (high <math>pK_b</math>)</b>		<b>Strongest base (Low <math>pK_b</math>)</b>	
<b>A</b>				
<b>B</b>				
<b>C</b>				
<b>D</b>				

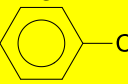
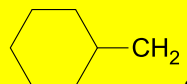
**Answer: C****Weakest base****Strongest base**

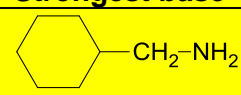
This is an amide and it is neutral

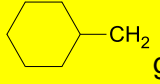


The lone pair of electron on the nitrogen atom can delocalised into the benzene ring making it less available for dative bond with the hydrogen protons.

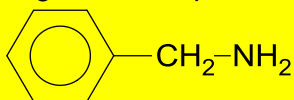


The electron directing cause by the  is not as strong as the  due to the present of the benzene ring



The electron directing effect cause by the  group is the greatest. This cause the lone pair of electrons to be more available for dative bond with  $H^+$ , resulting in a stronger base

For your knowledge, 2013 Paper 3 Q2(d)

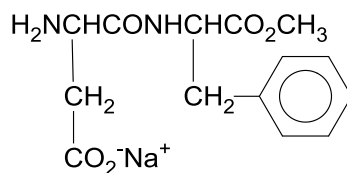


It is know that  $\times 10^{-4}$ ).

( $K_b = 2.18 \times 10^{-5}$ ) is less basic than  $CH_3NH_2$  ( $K_b = 5.6 \times 10^{-4}$ ).

The presence of the benzene ring affect the electron donating effect of the R-group.

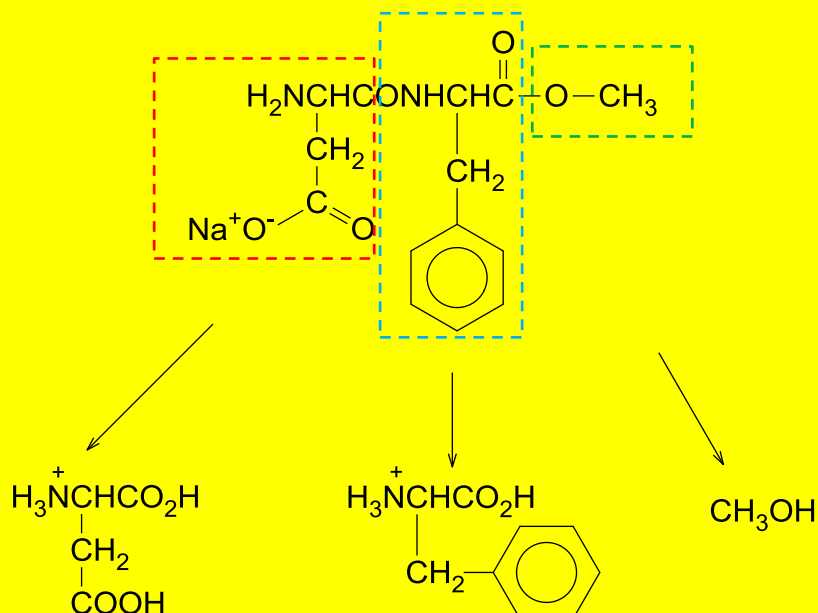
- 29** Aspartame is a dipeptide derivatives used as an artificial sweetener. Its general usefulness is restricted because it loses its sweetness after hydrolysis.



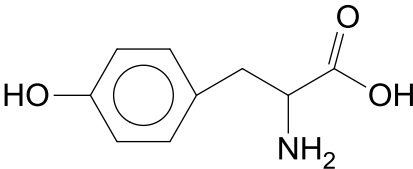
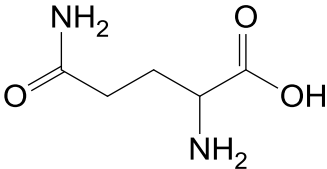
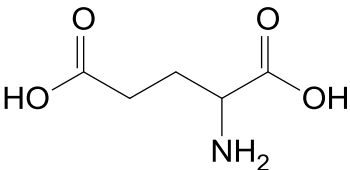
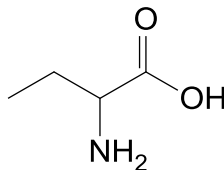
Which product would be formed after prolong acid hydrolysis.

	<p><b>A</b></p> $\begin{array}{c} \text{H}_3\text{N}^+\text{CHCO}_2\text{H} \\   \\ \text{CH}_2 \\   \\ \text{CO}_2^-\text{Na}^+ \end{array} \quad \text{and} \quad \begin{array}{c} \text{H}_3\text{N}^+\text{CHCO}_2\text{CH}_3 \\   \\ \text{CH}_2 - \text{C}_6\text{H}_5 \end{array}$	<p><b>C</b></p> $\begin{array}{c} \text{H}_3\text{N}^+\text{CHCO}_2\text{H} \\   \\ \text{CH}_2 \\   \\ \text{COOH} \end{array} \quad \text{and} \quad \begin{array}{c} \text{H}_3\text{N}^+\text{CHCO}_2\text{H} \\   \\ \text{CH}_2 - \text{C}_6\text{H}_5 \end{array} \quad \text{and} \quad \text{CH}_3\text{OH}$
	<p><b>B</b></p> $\begin{array}{c} \text{H}_3\text{N}^+\text{CHCO}_2\text{H} \\   \\ \text{CH}_2 \\   \\ \text{COOH} \end{array} \quad \text{and} \quad \begin{array}{c} \text{H}_2\text{NCHCO}_2\text{CH}_3 \\   \\ \text{CH}_2 - \text{C}_6\text{H}_5 \end{array}$	<p><b>D</b></p> $\begin{array}{c} \text{H}_3\text{N}^+\text{CHCO}_2\text{H} \\   \\ \text{CH}_2 \\   \\ \text{COOH} \end{array} \quad \text{and} \quad \begin{array}{c} \text{CH}_2\text{CO}_2\text{H} \\   \\ \text{CH}_2 - \text{C}_6\text{H}_5 \end{array} \quad \text{and} \quad \text{CH}_3\text{OH}$

**Answer: C**



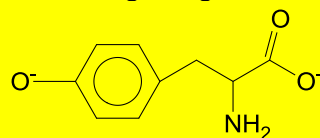
The diagram above shows the acidic hydrolysis reaction of the amide and ester group. Do note that since acid is present, all basic groups (the  $\text{NH}_2$ , the  $\text{COO}^-\text{Na}^+$ ) will be neutralised.

30	<p>Electrophoresis is a technique of separating and identifying amino acids. A solution of amino acids is absorbed into paper that is moistened with a buffer solution and stretched between two electrodes. Positively charged species move towards the cathode, negatively charged species towards the anode.</p> <p>With a buffer at pH 5, which amino acid will move most readily towards the cathode?</p>		
	<p><b>A</b></p> 	<p><b>C</b></p> 	
	<p><b>B</b></p> 	<p><b>D</b></p> 	

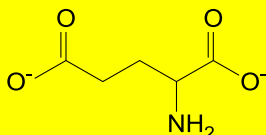
**Answer: D**

For A and B since its R-group are acidic, their isoelectric point will be lesser than 5. Thus in buffer at pH 5, they will be in an alkaline environment and will thus behave as an acid generating the anion and thus migrating to the anode.

Option A will generate

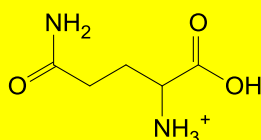


Option B will generate

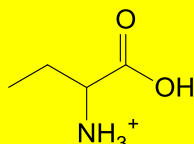


For C and D their R-group are neutral thus their isoelectric point reside around 7. Thus in buffer at pH 5, they will be in an acidic environment and thus will behave as an alkaline generating the cation and migrating to the cathode.

Option C will generate



Option D will generate



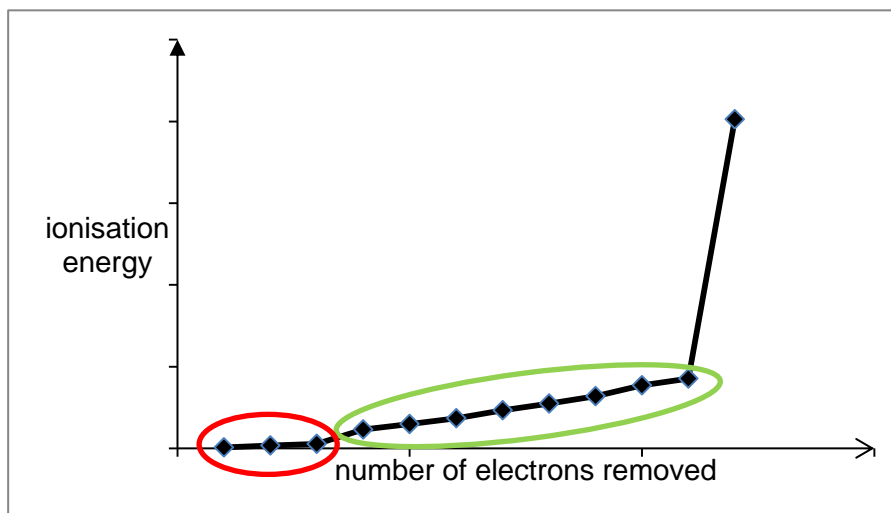
Since D has a lower  $M_r$  as compared to C, it will migrate more readily towards the cathode.

For **questions 31 – 40**, one or more of the numbered statements **1** to **3** may be correct. Decide whether each of the statements is or is not correct. The responses **A** to **D** should be selected on the basis of

<b>A</b>	<b>B</b>	<b>C</b>	<b>D</b>
1, 2 and 3 are correct	1 and 2 only are correct	2 and 3 only are correct	1 only is correct

No other combination of statements is to be used as correct response.

**31** The graph below shows the first twelve ionisation energies for element **T**.



Which of the following statements are true?

- |          |   |
|----------|---|
| <b>1</b> | It is in Group I of the Periodic Table.                     |
| <b>2</b> | It forms an oxide which dissolves readily with acid.        |
| <b>3</b> | It is in the third period (Na to Ar) of the Periodic Table. |

**Answer: C**

It is in group III of the Periodic Table as the first 3 consecutive electrons required lower energy. With this idea, Option 1 is definitely wrong and deploying MCQ skill, you should pick Option C (2 and 3) as the correct respond.

Being in group III, and having more than 10 electrons, it could be in the third period. The group III element could be aluminium whose oxide ( $\text{Al}_2\text{O}_3$ ) can dissolve readily in acid.

- 32** The following chemical reactions are listed below.
- Combustion of ethandioic acid:  $\text{C}_2\text{H}_2\text{O}_4 (\text{l}) + \text{O}_2 (\text{g}) \rightarrow 2\text{CO}_2 (\text{g}) + \text{H}_2\text{O} (\text{l})$
  - Evaporation of water:  $\text{H}_2\text{O} (\text{l}) \rightarrow \text{H}_2\text{O} (\text{g})$
  - Atomisation of magnesium:  $\text{Mg} (\text{s}) \rightarrow \text{Mg} (\text{g})$
  - Photolysis of chlorine :  $\text{Cl}_2 (\text{g}) \rightarrow 2\text{Cl} \cdot (\text{g})$

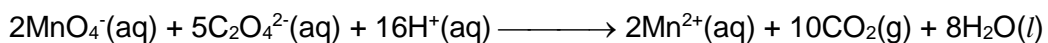
Which of the following statements are correct?

- |          |   |
|----------|---|
| <b>1</b> | $\Delta S$ is positive for all reactions. |
| <b>2</b> | $\Delta G$ is negative for all reactions. |
| <b>3</b> | $\Delta H$ is positive for all reactions. |

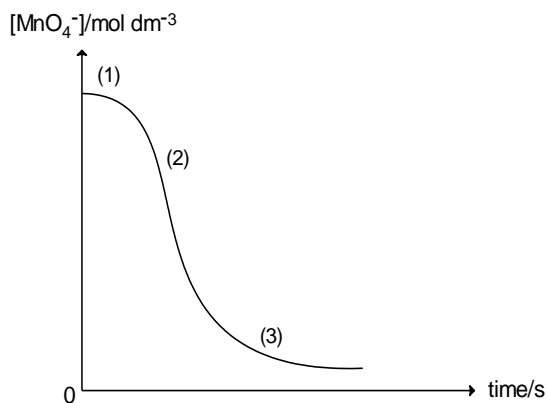
**Answer: D**

	$\Delta H$	$\Delta S$	$\Delta G$
Combustion of ethandioic acid	Always negative (Exothermic) For combustion, energy is always released.	Positive There is more moles of product than reactant	Since $\Delta H$ is exothermic and $\Delta S$ is positive, $\Delta G$ will always be negative at all temperatures.
Evaporation of water	Always positive (Endothermic) Energy need to be absorbed to overcome the intermolecular H-bonding in water.	Positive	$\Delta G = \Delta H - T\Delta S$ Dependent on temperature. Since $\Delta H$ and $\Delta S$ is positive, $\Delta G$ will only be negative if temperature increases.
Atomisation of magnesium	Always positive (Endothermic) Energy need to be absorbed to change the magnesium solid into magnesium gaseous atoms	Positive	
Photolysis of chlorine	Always positive (Endothermic) Energy is absorbed when bonds are broken	Positive	

**33** A reaction in which a product acts as a catalyst is said to be autocatalytic.



In the oxidation of ethanedioate ions by manganate(VII) ions, the reaction is accelerated by the  $\text{Mn}^{2+}$  ions produced during the reaction.



Which of the following statements can be deduced from the graph above?

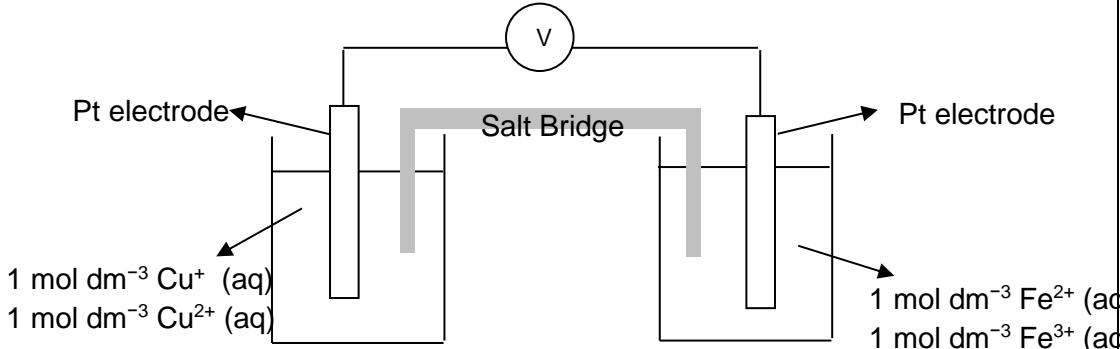
- |          |  |
|----------|--|
| <b>1</b> | Initial rate of reaction is the fastest at (1).                                |
| <b>2</b> | Reaction rate increases at (2) as $\text{Mn}^{2+}$ is generated.               |
| <b>3</b> | Reaction rate decreases at (3) as the concentration of the reactants decrease. |

**Answer: C**

From the graph the gradient at (1) is not the steepest. It is only at region (2) that the reaction rate increases due to the auto-generation of catalyst  $\text{Mn}^{2+}$ . As the reaction progresses, the concentration of reactants decrease and that's when reaction rate starts to dwindle down gradually.





<b>35</b>	<p>A student was investigating the possibility of an electrochemical cell using <math>\text{Cu}^{2+}/\text{Cu}^+</math> and <math>\text{Fe}^{3+}/\text{Fe}^{2+}</math> half-cells.</p>  <p>Which statements are true of the above set up?</p>
-----------	---

<b>1</b>	$E^\ominus_{\text{cell}} = +0.62 \text{ V}$ .
<b>2</b>	Copper and iron electrodes cannot be used instead.
<b>3</b>	When excess sodium hydroxide is added to the $\text{Fe}^{2+}/\text{Fe}^{3+}$ half-cell, the polarity of the electrodes are reversed.

**Answer: A (1 ,2 and 3 only)**

Option 1 is true:

From Data Booklet

$$E^\ominus(\text{Cu}^{2+}/\text{Cu}^+) = +0.15 \text{ V} \quad E^\ominus(\text{Fe}^{3+}/\text{Fe}^{2+}) = +0.77 \text{ V}$$

$$E^\ominus_{\text{cell}} = +0.77 - 0.15 = +0.62 \text{ V}$$

Option 2 is true: If copper and iron electrode are used. Other reaction will occur as equilibrium can be established between the metal and their ions.

Option 3 is true:

When  $\text{OH}^-$  is added to the iron half-cell, the half equation becomes



As compared to  $E^\ominus(\text{Fe}^{3+}/\text{Fe}^{2+}) = +0.77 \text{ V}$

Thus the iron containing compound half-cell would now undergo oxidation and the  $\text{Cu}^{2+}/\text{Cu}^+$  half-cell would now undergo reduction. Hence, the polarity of the electrodes are reversed

<b>36</b>	<p>Barium sulfate is less soluble than magnesium sulfate.</p> <p>Which of these factors are needed to be considered in order to explain this observation?</p>
<b>1</b>	$\Delta H_{\text{hyd}}$ of barium ion and magnesium ion.
<b>2</b>	$\Delta H_{\text{f}}$ of barium sulfate and magnesium sulfate.
<b>3</b>	Atomic radii of barium and magnesium.

**Answer: D (1 only)**

$$\Delta H_{\text{solution}} = (\Delta H_{\text{hydration of cation}} + \Delta H_{\text{hydration of anion}}) - \Delta H_{\text{lattice energy}}$$

The more soluble the sulfate, the more exothermic the  $\Delta H_{\text{solution}}$ .

Note that for both  $\Delta H_{\text{hydration}}$  and  $\Delta H_{\text{lattice energy}}$ , these terms are dependent on the ionic radii not the atomic radii.

Option 2 is not feasible as enthalpy change of formation is not required.

<b>37</b>	Which observation about bromine or its compounds is correct?	
	<b>1</b>	When aqueous lead(II) nitrate is added to aqueous sodium bromide, a cream precipitate is observed.
	<b>2</b>	When sodium bromide is treated with concentrated sulfuric acid, a gas that turns moist blue litmus paper red is evolved.
	<b>3</b>	Silver bromide is soluble in both dilute and concentrated ammonia solution.

Answer: **B (1 and 2 only)**

Option 1:  $\text{Pb}^{2+}(\text{aq}) + \text{Br}^{-}(\text{aq}) \rightleftharpoons \text{PbBr}_2(\text{s})$

**PbBr<sub>2</sub>(s) is a cream ppt** (same colour as AgBr ppt)

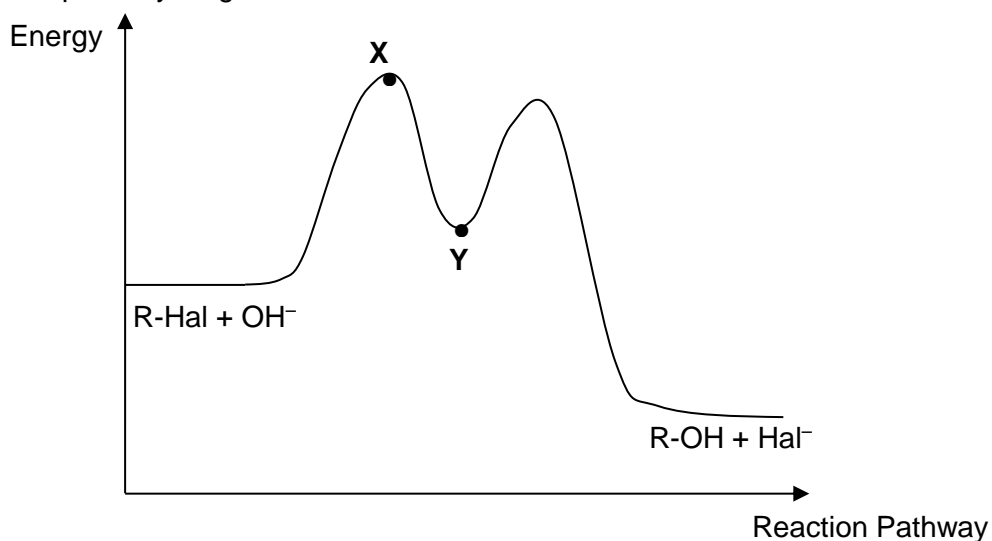
Option 2:  $\text{NaBr} + \text{H}_2\text{SO}_4 \rightarrow \text{HBr} + \text{NaHSO}_4$

$2\text{HBr} + \text{H}_2\text{SO}_4 \rightarrow \text{SO}_2 \text{ is acidic and turns moist blue litmus paper red} + \text{Br}_2 + 2\text{H}_2\text{O}$

Option 3: AgBr is only soluble in concentrated ammonia.

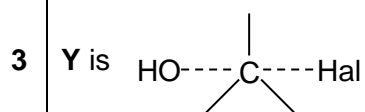
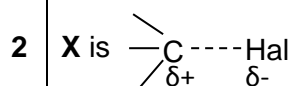
<b>38</b>	The catalytic converter is part of the exhaust system of modern cars. Which reactions occur in the catalytic converter?	
	<b>1</b>	$2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2$
	<b>2</b>	$2\text{NO} + \text{CO} \rightarrow \text{N}_2 + 2\text{CO}_2$
	<b>3</b>	$\text{C}_x\text{H}_y + (2x + \frac{y}{2})\text{NO} \rightarrow x\text{CO}_2 + \frac{y}{2}\text{H}_2\text{O} + (x + \frac{y}{4})\text{N}_2$
<p><b>Answer: A (1,2 and 3)</b></p> <p>Catalytic converter function to catalyse the</p> <ol style="list-style-type: none"> <li>1. Oxidation of carbon monoxide to carbon dioxide</li> <li>2. Reduction of nitrogen oxide to nitrogen and oxygen gas by carbon monoxide.</li> <li>3. Complete combustion of hydrocarbons by oxygen or nitrogen oxide</li> </ol> <p>Reduction of nitrogen oxide to nitrogen and oxygen gas by carbon monoxide.</p>		

- 39** Halogenoalkanes react with aqueous alkali. One mechanism of this reaction has the reaction pathway diagram shown below.



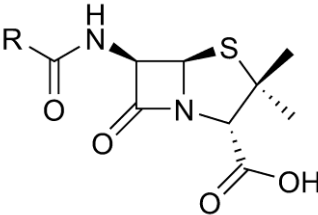
Which statements are true? (---- indicates a partial bond)

- 1** The reaction is a type of nucleophilic substitution.



**Answer: B (1 & 2 only)**

Y is a carbocation intermediate, not a pentavalent transition state.

40	Which of the following phenomena involves denaturation of proteins?	
	1	Heating of egg white.
	2	Production of bean-curd from soy milk.
	3	Dissolving Penicillin in a test tube of hot acid.   <p style="text-align: center;">Penicillin</p>
<p><b>Answer: B (1 and 2 only)</b></p> <p>Option 1 involves denaturation:            Heating during cooking causes the <b>albumin (protein)</b> in egg white to <b>denature</b>.            Heating will <b>disrupt</b> the <b>weak Van der Waals forces</b> (and to a lesser extent, <b>hydrogen bonds</b>) holding the <b>quaternary, tertiary</b> and <b>secondary</b> structures, resulting in a more disordered arrangement.</p> <p>Option 2 involves denaturation:            Extract from 2010 H2 Paper 3 Q3, "Dofu (bean curd) is made by coagulating soy milk and then pressing the curds between fine cloth to extrude most of the moisture. Coagulating agents that have been used include certain salts, acid or enzymes. <b>Coagulation is due to the denaturation of the protein in the soy milk.</b>"</p> <p>Similar process in food preparation include cheese making, yogurt making and butter making. (Making of Margarine is <b>not</b> denaturation but addition of hydrogen into poly unsaturated alkenes)</p> <p>Option 3 does not involve denaturation as it is merely an acidic hydrolysis process.</p>		

**END OF PAPER 1**